In Situ Dechlorination of Solvents in Saturated Soils

A Partnership between US AFRL/MLQ, US Navy, US EPA NRMRL, Academia, and Industry
(AFRL/MLQ), Tyndall AFB, Florida

THE PROBLEM

Current aerobic treatment methods for remediation of chloroethene-contaminated groundwater are limited and often expensive. Development of a cost-effective in situ anaerobic biotreatment technology for chlorinated solvent-contaminated groundwater is urgently needed.

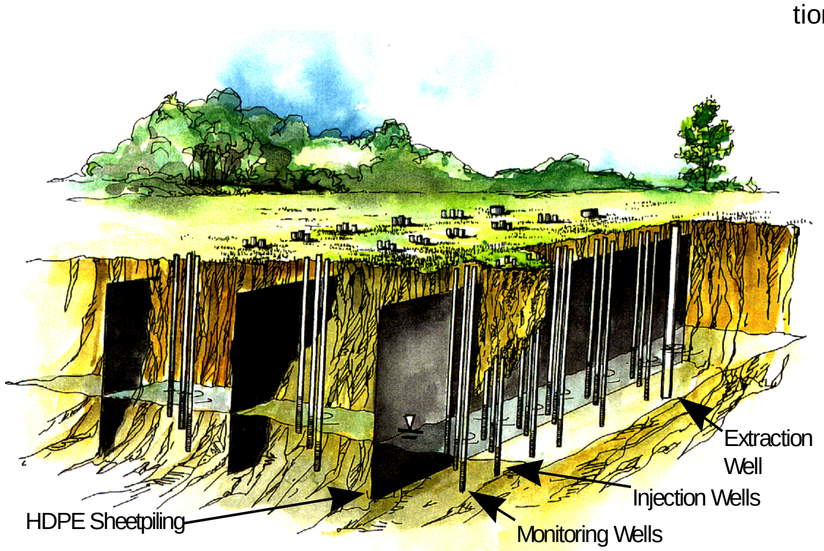
BACKGROUND

A microbial culture capable of rapidly dechlorinating tetrachloroethene (PCE) to ethene (ETH) with efficient use of electron donors has been isolated. Field studies have shown reductive dechlorination of chloroethenes to be stimulated by the addition of electron donors. This field effort utilizes indigenous bacteria and the addition of various electron donors to stimulate the degradation of PCE to ETH in the subsurface at Naval Air Station Fallon (NASF), NV. Dechlorination will also be investigated through natural attenuation and use of iron electrodes. The project is designed to achieve a mass balance on the electron donors, electron acceptors, and microbial carbon/energy sources.

LABORATORY STUDIES

Cornell University first reported the complete biological dechlorination of PCE to ETH. Reductive dechlorination of chloroethenes requires the addition of electron donors to serve as H_2 precursors. Some electron donors offer advantages over others because they are not direct methanogenic substrates; they eliminate competition for the donor; and they produce H_2 at low levels allowing for complete PCE mineralization.

Cornell University discovered several electron donors which stimulate anaerobic fermentation, H_2 production, and reductive dechlorination of PCE in NASF soil. These studies suggest that slow release of H_2 provides the best condition for suppressing methanogenic competition and enhancing PCE dechlorination.

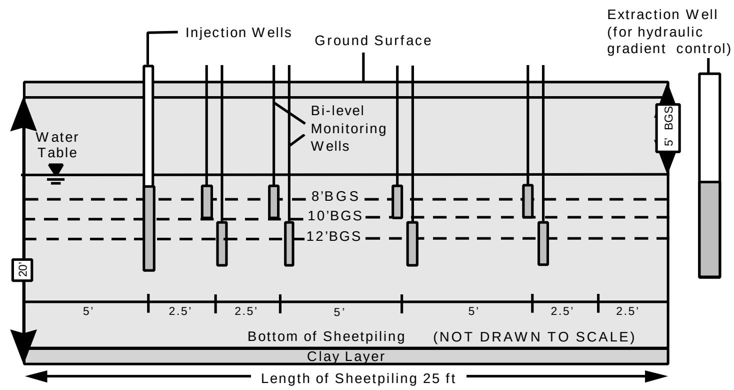


CONCEPTUAL DRAWING

THE APPROACH

The site consists of an unlined, earth-bermed fire training pit. Sandy soils cover the site over a layer of clay-rich silts and sands. Groundwater is perched on a regional lake bed clay layer at a depth of 8 to 10 ft BGS. Maximum PCE and TCE concentrations are 680 and 340 μg/L, respectively.

This field study involves the use of five semi-enclosed treatment lanes separated by six HDPE sheetpiles. Each lane represents a unique treatment scenario. Two inside lanes receive organic electron donors (lactate or ethanol plus benzoate) and nutrients (vitamins plus yeast extract). The third inside lane receives high yeast extract concentrations plus vitamins. One outside lane is a control lane to monitor natural attenuation of PCE. An iron electrode was installed in the second outside lane to produce H_2 via iron oxidation and reduction of H^+ ions in water to H_2. Analyses include PCE, dechlorination byproducts, electron donor concentrations, CH_4, SO_4^{2-}, NO_3^-, DO, pH, and conductivity.



TYPICAL TREATMENT LANE - SECTION VIEW

PAYOFF

This effort will validate enhanced in situ reductive dechlorination in a field situation. A detailed understanding of in situ dechlorination will lead to more efficient, cost-effective and reliable strategies for bioremediation of PCE and related compounds. Understanding the microbiology will help researchers develop predictable processes to remove chlorinated solvents from the environment. The results from this effort feed the RABITT protocol, another AFRL/MLQE effort funded by the DOD Environmental Security Technology Certification Program (ESTCP).

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